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ABSTRACT

In this paper the belief is stated that researchers need to develop some type of conceptual frame for improving continuity of studies and specificity of treatment. This paper describes such a conceptual frame and its implications for research. The paper states that the framework was designed to help researchers identify, classify, and/or quantify the factors affecting studies on instructional processes. Nine categories are listed (learner variables, teacher variables, organizational structure of school or classroom, settlement patterns, educational objectives, method variables; functional analysis of classroom tasks, management variables, and evaluation) and subsequently analyzed. (JA)

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Variables To Consider In Planning Research For Effective Instruction: A Conceptual Framework

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"Nowhere in education is there greater need for conceptual systems to guide theory-building, research, and planning than in the field of curriculum. By conceptual systems, I mean a carefully engineered framework designed to identify and reveal relationships among complex, related, interacting phenomena; in effect, to reveal the whole where wholeness otherwise might not be thought to exist."

- John Goodlad

One purpose for reviews of educational research is to bring to researchers' attention major concerns with respect to the state of the art. In reading reviews pertaining to pedagogical techniques and curriculum development two concerns readily detected are (1) the lack of continuity of studies and (2) inadequate specification of treatments. Goodlad (1969) addresses himself to the first problem by citing the need for curriculum scholars to stake out domains of inquiry with enough clarity so that successive studies are integrated into a whole, gaps identified, and new studies initiated. Baker (1969) in reference to the latter, has stated that the lack of treatment specification has often made the application of elegant procedures a waste of time and money at best, and a smokescreen at worst.

The charge to researchers is implicit, namely, to develop some type of conceptual frame for improving continuity of studies and specificity of treatment. Without conceptual guides, research on pedagogical techniques and curriculum development may remain somewhat haphazard, thus failing to provide the necessary data to teachers in their efforts to determine the

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most effective instruction for individuals in terms of their interests, aptitudes and learning styles.

The purpose of this paper is to describe the conceptual frame "Variables to Consider in Planning Research for Effective Instruction" and its implications for research. The framework was designed to help researchers identify, classify, and/or quantify the factors affecting studies on instructional processes. It has broad enough dimensions to include all content areas and levels of curriculum, suggests general hypotheses to be explored, lends continuity to successive studies and facilitates specificity of treatments. Although the conceptual frame is not, in and of itself, a panacea for the ills of educational research it is the writer's hope that it may act as a catalyst in generating new ideas for improving clinical and/or experimental investigations on instruction. It is presently being used in the Mathematics Education Clinic, University of South Florida, to guide clinical research designed to study the symptomatology and etiology of learning difficulties experienced by children in acquiring mathematics concepts, skills, and principles.

Description

The conceptual frame "Variables to Consider in Planning Research for Effective Instruction" is organized into nine categories:

A. Learner Variables

B. Teacher Variables

C. Organizational Structure of School or Classroom

D. Settlement Patterns (Urban-Suburban, Rural)

E. Educational Objectives (Content Statement → Behavioral Indicators)

F. Method Variables

G. FACT (Functional Analysis of Classroom Tasks)

H. Management Variables (Learner or Curriculum)

I. Evaluation (Formative and/or Summative)

Categories A through D comprise variables to be considered antecedent to the instructional process, E through H focus on the instructional process, and I relates to the result or product of the process.

Discussion of the variables in categories A,B,C, and D will be limited since they have been examined at length by others (Aiken, Jr. 1970, Jensen 1968, Rohwer, Jr. 1971, Rosenshine 1970, Zierkel 1971). A description of these categories is presented in outline form in Figure 1 (The list of variables within a category is not exhaustive.) Although most would agree as to the importance of these factors in studying instructional processes they are often neglected. As Scannell (1969) states, "Authors of research articles in the past have given too much space to a section called 'Method' and relatively too little to a description of the relevant characteristics of the factors affecting the study".

If research findings are to be meaningful, investigators must be able to describe in detail the physical and socio-emotional characteristics of the learner and teacher, the entering behavior of both, and the environment within which they interact. In effect, a symptomatic diagnosis needs to be completed on the learner, teacher and environment. The fact that it would be very difficult to collect sufficient data on large samples or populations with respect to these variables might advance the cause for clinical research where one traditionally works with small groups or individuals. In either case, clinical or experimental, if insufficient data are collected it should be reported as limitations of the study.

Once consideration of the variables in categories A through D is complete, some decisions concerning the instructional process must be made. If the acquisition of a particular topic through different instructional procedures is to be studied, it must be decided whether the educational

A. Learner Variables

1. Organismic
   a. Characteristics of the Learner - age, sex, intelligence level (WISC, SB, etc.) socioeconomic class (Warner, Meeker, and Eells), Ethnic (racial, religious, nationality, cultural, language division), physical disabilities etc.
   b. Mediating Processes (Emotional/Socio-emotional) - fear, anger, love, anxiety, motivation, aggression, stress, empathy, competitiveness, impulsive, reflective, etc.
2. Entering Behavior
   a. Cognitive - knowledge, concepts, problem solving, etc.
   b. Affective - feelings, interests, etc.
   c. Psychomotor - muscular movement.
3.

B. Teacher Variables

1. Organismic
   a. Characteristics of the Teacher - age, sex, intelligence level (WISC, SB, etc.) socioeconomic class (Warner, Meeker, and Eells,), Ethnic (racial, religious, nationality, cultural, language division), physical disabilities etc.
   b. Mediating Processes (Emotional/Socio-emotional) - fear, anger, love, anxiety, motivation, aggression, stress, empathy, competitiveness, impulsive, reflective, etc.
2. Entering Behavior
   a. Cognitive - knowledge, concepts, problem solving, etc.
   b. Affective - feelings, interests, etc.
   c. Psychomotor - muscular movement.
3.

C. Organizational Structure of School or Classroom

1. Physical - (Self-Contained, Open Classrooms etc.)
2. Teachers - (Team Teaching - Departmental etc.)
3. Learners - (Homogenous, Heterogeneous, Individualized Instruction, etc.)
4.

D. Settlement Patterns (Urban-Suburban, Rural)

1. Economic Contingencies - Home, Neighborhood, Village, Town, City, County, State, National, International.
2. Political Contingencies - Home, Neighborhood, Village, Town, City, County, State, National, International.
3. Socio-demographic Contingencies - Home, Neighborhood, Village, Town, City, County, State, National, International.
4.

Figure 1. Outline Description of Categories A, B, C, and D - Variables to Consider in Planning Research for Effective Instruction: A Conceptual Frame.

objectives of such are appropriate for the learner(s), teacher(s) and existing environment. Or, on the basis of the data collected one must select a suitable topic and procedures for examination.

Category E, Educational Objectives is organized into three domains: Cognitive, Affective, and Psychomotor (Bloom et. al. 1956). These domains simply facilitate labeling the type of educational objective; other schemas may be used or none at all.

In this frame an educational objective is defined as having two components, (1) the content statement and (2) the behavioral indicator. The content statement is a statement or definition of a concept, principle, skill, or attitude; it denotes no learner behavior. The specific overt behavior(s) the learner must exhibit to indicate acquisition of a given content statement are described by behavioral indicators. That is, a distinction is made between learning and performance. For example, a content statement for the mathematics principle place value may be stated as follows - A multidigit numeral names a number that is the sum of the products of each digits face value and its place value. Listed below are some behavioral indicators associated with this content statement.

> Given a set of "n" blocks, the child will arrange them in groups of tens and ones, represent the grouping using straws (face value) and cups (place value) and state and/or write the two digit numeral associated with the set.
>
> Given a two digit numeral orally and/or in written form, the child will represent the numeral using straws (face value) and cups (place value), and arrange a set of blocks into groups of tens and ones as indicated.
>
> Given a set of "X's" on paper the child will circle as many groups of ten as possible, then represent the groups of tens and remaining ones on an abacus, and state and/or write the two digit numeral associated with the grouping.
>
> Given a two digit numeral orally the child will represent the numeral on an abacus.

Given a two digit numeral in written form the child will represent it on an abacus.

Shown a two digit numeral represented on an abacus the child can state the numeral.

Shown a two digit numeral represented on an abacus the child can write the numeral.

Given a three digit numeral orally the child will write it in expanded notation using multiples of hundreds, tens, and ones.

Given a three digit numeral orally the child will write it in expanded form as follows: $(a \times 100) + (b \times 10) + (c \times 1)$.

Given a three digit numeral orally the child will write it in expanded form using exponential notation, i.e. $(a \times 10^2) + (b \times 10^1) + (c \times 10^0)$.

This list is not exhaustive. Further, since it is hypothesized (Brownell and Hendrickson, 1950) that a learner acquires a concept or principle in stages, the number and complexity of behaviors exhibited indicates varying levels of attainment.

The distinction between learning and overt behavior is supported in the writings of Tolman (1956), Wilson (1967), Cronbach (1969), and Ebel (1972).

> "The person who insists on 'behavioral' objectives is denying the appropriateness and usefulness of constructs. The educator who states objectives in terms of constructs (self-confidence, scientific attitude, the habit of suiting one's writing style to his purpose) regards observables as indicators from which the presence of certain dispositions can be inferred. He will not, however, substitute 'volunteers ideas and answers in class' for 'self-confidence'. From the construct point of view, behavior such as this is an indicator of confidence, not a definer. No list of specific response-to-situations, however, lengthy, can define the construct... (Cronbach 1969).

To bring about the desired behaviors stated in educational objectives manipulation of the environment must occur. Categories F, G and H, Method FACT, and Management Variables, focus on procedures for describing and/or designing instructional sets or environments.

Three basic theories of instruction, didactic (A), Socratic (B), and discovery (C), are used as a basis for generating and describing the method

variables in category F. Didactic is defined as telling, lecturing or reading, socratic as structured questioning, and discovery (Glennon 1966) as a situation in which the learner has responsibility for setting his own goals and learning experiences for the purpose of creating new knowledge. A pure didactic, socratic or discovery method is seldom observed in instructional situations but rather combinations of the three. Hence, in this framework, method is designed and/or coded as a function of these combinations (see Figure 2). For example, method AB indicates that a learner was told or read some information, questioned, and then expected to exhibit or exhibited a desired behavior. Method BA is the reverse process of AB. A "guided" discovery approach may be coded as BC, CB, ABC, etc.

Method:	Didactic (A)	Socratic (B)	Discovery (C)	
A...	AB...	BA...	ABC...	
B...	AC...	CA...	ACB...	CBA...
C...	BC...	CB...	BCA...	CAB...
		CB^1 (non-directive)	BAC...	

Figure 2. Coding For Method Variables.

Additional discrimination of method variables can be achieved by using subscripts ($A_2 B_1$ - two bits of information given, one question → behavior exhibited). Also, a special code CB^1 is included in this schema and is associated with the non-directive or psychotherapeutic approach (Glennon, 1966) in which affective learning rather than cognitive learning is dominant.

Category G, FACT, (Ober and Uprichard, 1970) is designed explicitly to classify, examine, or quantify the instructional stimuli that are available to the learner in a given situation. The categories of the system originate from the synthesis of two components: a sensory component and a cognitional

component. Each of these two components is characterized by its own unique structure. The sensory component is divided into five exclusive subcomponents - Visual (V), Auditory (A), Tactile (T), Smell (S), and Taste (T^1). The cognitional component is divided into three subcomponents - Concrete (C), Representative (R) and Abstract (A). Almost all instructional stimuli occurring in the classroom can be categorized systematically into one of the thirteen categories that are formed by the pairing of these eight subcomponents as shown in Figure 3.

Sensory	Cognitional: Concrete	Representative	Abstract
Visual	VC 1	VR 2	VA 3
Auditory	AC 4	AR 5	AA 6
Tactile	TC 7	TR 8	TA 9
Smell	SC 10	SR 11	
Taste	T^1C 12	T^1R 13	

Figure 3. Category Classifications For Instructional Stimuli - FACT.

To facilitate a better understanding of the categories, a description of each is given in Figure 4. It is intended that the categories described are mutually exclusive. That is, no stimulus could be categorized in more than one category at a given time (instant). For example, if a teacher touches a real object around which the instruction is centered and does not pass it to the children so they touch it, the stimulus is not recorded as Tactile Concrete, but only Visual Concrete. Only the stimuli that affects the learners are considered.

Stimuli classified within a given category may differ in physical objectivity (size, color, and shape) and along a social dimension. Instruction on the mathematics principle place value, using candies as objects to

Description of Stimulus Categories

1. VISUAL CONCRETE: Viewing the real or actual object or thing around which the instruction is centered.

2. VISUAL REPRESENTATIVE: Viewing a model (two-dimension or three-dimensional) or diagram representing an object, thing, or idea around which the instruction is centered.

3. VISUAL ABSTRACT: Reading a written description of something related to the object, thing, or idea around which the instruction is centered.

4. AUDITORY CONCRETE: Hearing the real or actual object or thing around which the instruction is centered.

5. AUDITORY REPRESENTATIVE: Hearing a representation of the object, thing, or idea around which the instruction is centered.

6. AUDITORY ABSTRACT: Hearing a verbal description of something related to the object, thing, or idea around which the instruction is centered.

7. TACTILE CONCRETE: Feeling physically and/or kinesthetically the real or actual object or thing around which the instruction is centered.

8. TACTILE REPRESENTATIVE: Feeling physically and/or kinesthetically a representation of an object, thing or idea around which the instruction is centered.

9. TACTILE ABSTRACT: Feeling physically and/or kinesthetically a verbal description of something related to the object, thing, or idea around which the instruction is centered.

10. SMELL CONCRETE: Smelling the real, or actual object or thing around which the instruction is centered.

11. SMELL REPRESENTATIVE: Smelling an artificial scent representative of the real or actual object or thing around which the instruction is centered.

12. TASTE CONCRETE: Tasting the real or actual object or thing around which the instruction is centered.

13. TASTE REPRESENTATIVE: Tasting an artificial substance representative of the real or actual object or thing around which the instruction is centered.

Figure 4 - Functional Analysis of Classroom Tasks (FACT)
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group, may be more effective with some learners than instruction using blocks; yet both (candies and blocks) could be considered Visual Concrete or Tactile Concrete stimuli at various times during a lesson.

As a planning model, FACT can be used as a means for selecting and organizing the stimuli (i.e., materials, aids, etc.) that are to be presented in the instructional phase of a lesson. When used as an observational system, it is useful in research activities as a data collection device as well as a means for providing the teacher with meaningful feedback describing certain aspects of his own behavior. Thus, the system can assist in planning instruction and, in turn provide "objective" evidence describing performance.

Theoretically, the FACT system can be employed effectively in any content area and at any level of sophistication providing that the user is aware of the specific objectives that are set forth in a particular instructional situation. (This gives rise to the acronym FACT - Functional Analysis of Classroom Tasks.)

The management variables included in category H relate to either the learner or the curriculum. Variables such as motivation (extrinsic), schedules and types (stimuli) of reinforcement, practice, and time (allowed per task) deal with the management of the learner while sequencing, spiraling, and time regulate the curriculum. These variables are considered mainly inter-task in nature rather than intra-task as are the variables in categories F and G.

Management variables play a significant role in instruction, and if not examined and controlled, can have a confounding effect on research results. Past research on these variables has been extensive.

A brief discussion of category I, Evaluation will complete the description of this framework. No framework or model for instruction would be complete without such a category since evaluation serves as a basis for

making decisions with respect to instructional processes or procedures. The numerous articles, chapters, and books written on this subject attest to its importance.

Two types of evaluation are considered in this framework in planning research for effective instruction, formative and summative. Formative evaluation occurs during the development of an instructional process, procedure, or program. It is "on going" and provides data for making decisions as to the feasibility of specific techniques in bringing about a desired behavior. Formative evaluation is associated with the systematic manipulation of the variables in categories F, G, H, - Method, FACT, and Management Variables. Summative evaluation is concerned with the "finished" product of an instructional process or program. It is used to determine the degree of attainment achieved by the learner of a given concept, principle, or skill. This type of evaluation is usually done with paper and pencil tests, and the results of the tests are compared to some norms. Summative evaluation could also be used to compare the learning products of two or more programs of instruction.

Both formative and summative evaluation may measure cognitive, affective, and/or psychomotor outcomes.

An outline, description of categories E, F, G, H is provided in Figure 5.

Implications for Research

> "Perhaps our greatest hope of achieving equality of educational opportunity lies in the possibility of finding significant patterns of individual differences in the development of abilities and in taking advantage of these differences to create the optimal instruction pupil interaction."
>
> Jensen (1968)

E. Educational Objective (Content Statement → Behavioral Indicators)

1. Cognitive - Knowledge, concepts, problem solving, etc.
2. Affective - feelings, interests, etc.
3. Psychomotor - Muscular movement.

F. Method:

Didactic (A)	Socratic (B)	Discovery (C)
A...	BA...	ABC...
B...	CA...	ACB... CBA...
C...	CB...	BCA... CAB...
	CB^1 (non-directive)	BAC...

G. FACT (Functional Analysis of Classroom Tasks)

Cognitional

Sensory	Concrete	Representative	Abstract
Visual	VC 1	VR 2	VA 3
Auditory	AC 4	AR 5	AA 6
Tactile	TC 7	TR 8	TA 9
Smell	SC 10	SR 11	
Taste	T^1C 12	T^1R 13	

H. Management Variables (Learner or Curriculum)

1. Motivation (extrinsic, schedules and types of reinforcement, etc.)
2. Practice
3. Sequence
4. Spiraling
5. Time
6.

I. Evaluation - (Formative and/or Summative)

1. Cognitive (Type of item - T-F, M-C, ES, F-B, etc., Oral, Written, Stimuli employed).
2. Affective
3. Psychomotor

Figure 5. Outline Description of Categories E, F, G, H, and I; Variables to Consider in Planning Research For Effective Instruction: A Conceptual Frame.

The main purpose of this discussion will be to illustrate the usefulness of the conceptual frame, "Variables to Consider in Planning Research for Effective Instruction," for (1) specifying treatments and (2) lending continuity to successive studies.

As previously stated the framework is being used in a Mathematics Education Clinic to guide research designed to study the symptomatology and etiology of learning difficulties experienced by children in acquiring mathematics concepts, skills, and principles. Children are referred to the clinic by parents, teachers, or principals. Once accepted, a child is assigned to a clinician (usually an in-service teacher or senior level student enrolled in clinic courses) who will work with him for two one hour sessions per week for eight weeks. It is the responsibility of the clinician to do a symptomatic diagnosis of the child's mathematics abilities, to experiment with various treatments in attempting to overcome any difficulties, and to prepare a case study which describes in detail the work completed.

In preparing the case study as much data as possible is collected on variables such as those listed in the framework under categories A, B, C and D (Learner Variables, Teacher Variables[1], Organizational Structure of School and Classroom, and Settlement Patterns-see Figure 1). The data is secured through interviews with parents and school teachers, examination of school records, and administration of a standard diagnostic mathematics test to the child. In special cases an individual intelligence test is given to a child by a graduate student in School Psychology. In addition, each clinician takes a diagnostic mathematics test and writes an essay about himself.

After problem areas are identified using the standard diagnostic mathematics test, teacher-made subtests are administered to the child to further pinpoint the difficulties. A profile of these results is prepared with the

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[1]Teacher in this case refers to clinician

aid of a mathematics taxonomy (Wilson, 1965) and appropriate educational objectives determined. A log of the work done by the clinician in helping the child to achieve these objectives is recorded on planning forms such as that presented in Figure 6.

The components of the planning form are directly related to categories E, F, G, H, and I in the framework (Educational Objectives, Method, FACT, Management Variables, and Evaluation). The boxes to the left of the content statement and behavioral indicator (Educational Objective) are used for coding. A mathematics taxonomy (Wilson, 1965) is used to code the content statement and Bloom's Taxonomy (1956) to code the indicator. The same content statement may appear on a number of planning forms but usually each time with a different behavioral indicator. If both the content statement and indicator remain constant from one planning form to another then systematic changes are being made in method, stimuli or assessment of objective.

Provision for one change in method and/or stimuli is made on a planning form by including a planned procedures column (p) and an actual procedures column (a). Planned and actual procedures are indicated by simply placing a check mark across from the appropriate code. The general description of procedures should correlate with the coded method and stimulus variables. Also, management of the learner is reported in this description.

The last two components on this form, assessment of objective and evaluation and inferences are closely related. The assessment of objective must include examples of specific tasks or items the learner is to do. Under evaluation and inferences it must be reported whether the learner was successful or not in completing these tasks or items and why (if possible).[1]

In this schema, the conceptual framework allows for specificity of treatment and suggests successive treatments through the systematic manipulation

---

[1] A number of planning forms are used in one hour of instruction.

NAME: _____ SESSION: _____ CLINICIAN: _____

DATE: _____

☐ Content Statement: Place Value - A multidigit numeral names a number that is the sum of the products of each digits face value and place value.

☐ Behavioral Indicator: Given a set of "n" blocks, the child will arrange them in groups of tens and ones, represent the grouping on an abacus, and write the two digit numeral associated with the set.

METHOD			STIMULI		
(p)		(a)	(p)		(a)
	A	x	x	VC	x
	B		x	VR	x
	C			VA	
x	AB			AC	
	AC			AR	
	BC		x	AA	x
	BA		x	TC	x
	CA		x	TR	x
	CB			TA	
	CB'			SC	
	ABC			SR	
	ACB			T'C	
	BCA			T'R	
	BAC				
	CBA				
	CAB				

General Description of Procedures:

Materials - Blocks (VC, TC) and Abacus (VR, TR)

First, I will explain (AA) and illustrate step-by-step the process I want the child to follow in completing the task. I will then guide him through the process using questions.

Assessment of Objective: The child is to be tested on the above task using the following sets of blocks - 25, 20 and 16.

Evaluation and Inferences: The child had no trouble performing the task with sets of 25 and 16 blocks. However he could not complete the task with the set of 20 blocks. More work is needed in using zero as a place holder.

*The child refused to answer questions during instruction. (See change in method.)

Figure 6. Planning Form

of relevant variables. For example, in working with an individual on basic addition facts of whole numbers the following stimulus-response situations may be examined:

	Stimulus	→	Kinesthetic Behavior	→	Response
1.	VA	→	K	→	AA
2.	VA	→	K	→	VA
3.	AA	→	K	→	AA
4.	AA	→	K	→	VA

In the first two situations the learner is shown two single digit addends and is expected to state or write the sum. In the latter two situations the learner is given two addends orally and must state or write the sum. Would an individual's scores vary if tested on the same basic facts in each one of the stimulus-response situations above? How successful would the individual be if more complex situations were generated?

Clinical procedures such as that described can lead to discovery of significant patterns of instruction for different kinds of learners in acquiring mathematics concepts, skills, and principles, and generate hypotheses to be tested in quasi-experimental and experimental studies.

Researchers designing or evaluating experimental studies on mathematics instruction may also find the conceptual framework, "Variables to Consider in Planning Research for Effective Instruction" helpful. Without careful specification of treatments significant findings of studies may be due to confounding variables rather than independent variables. This framework can be used as a guide in helping to determine whether variables, other than independent variables, which may affect the study are, or remain constant between treatments. Further, any systematic process used for describing treatments can also be used to design successive experimental studies having continuity.

In fine, it should be emphasized again that this framework is not a panacea for the ills f educational research. It is but one attempt to create a system that both researchers and teachers could utilize in the study of instruction. Numerous models and frameworks on instruction have appeared in the literature, however, only time and hard work will determine the usefulness of each in providing optimal instruction for different kinds of learners. As Van Engen (1967) implies, educational research is in its infancy and infants don't eat steak.

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